Acute spinal cord injury increases callus formation during fracture healing in an experimental rat model

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Aims
In patients who have sustained traumatic brain or acute spinal cord injuries associated with fractures of extremities the rate of new bone formation around the fracture site is increased. Moreover heterotopic ossification is a fairly common complication in spinal cord trauma and brain injuries1,2. The knowledge about the background mechanisms affecting bone formation after trauma of the central nervous system is limited3. Upgrading understanding of the pathomechanisms might give treatment options for heterotrophic ossifications and in addition for delayed bone union. The objective of this study was to establish a reproducible animal model in order to study the influence of acute spinal cord injury on fracture metabolism.

Method
A mid diaphyseal femur osteotomy was created in 20 female sprague dawley rats. Therefore the right femur was exposed and a PEEK plate with angular stable fixation (AO Development Institute, Switzerland) was fixed. A transverse osteotomy was performed using a gigli wire saw resulting in a 2 mm gap. The animals were randomly assigned into intact control and spinal cord injury. The spinal cord was injured at the day of osteotomy using a balloon compression technique4. After laminectomy of the T10 arch, a catheter is inserted into the epidural space, advanced cranial to the T8-9 spinal level, inflated and hold for 20 min. Neurological deficits were classified using BBB score (0-21 Points). Callus formation was analyzed at 14 days after surgery using µCT (1076, SkyScan, Belgium) and histology (decalcification, paraffin section, HE-stain).

Results
The radiological scout view of the femurs showed increased callus formation in animals with spinal cord injury at 14 days after surgery. In contrast to control group the callus formation was not restricted to the gap and extensive bone formation was observed at periosteal sites (0 out of 10 in control, 8 out of 10 in injury group) (Fig. 1). The newly formed bone volume within the gap was BV/TV 0.11 ± 0.19 (mean ± SD) for control and BV/TV 0.51 ± 0.43 for injury group (Tabl.1). The neurological deficit after spinal cord injury was incomplete and characterized using BBB-score with mean values of 3.4 points at day 1 increasing to 11.4 points at day 14. No correlation was found between newly formed callus volume and BBB score. Histology revealed that mature woven bone was formed 14 days after spinal trauma at periosteal sites.
Femurosteotomy + ASCI | Femurosteotomie

Figure 1. Scout view of the femurs. ASCI and control group

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<th>BV/TV Femurosteotomy + ASCI vs controll</th>
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Table 1. BV/TV of the femurs and control group

**Conclusion**
To our knowledge this is the first reproducible animal model to study the increased bone formation in acute spinal cord injury. The femur osteotomy was fixed with a rigid angular stable screw-plate-device that allows maximal standardization of the bone injury and decreases the influence of body motion on the process of bone healing. Increased periosteal callus formation was found at 14 days after spinal cord injury. The model seems to simulate the clinical findings in patients with spinal trauma. Factors that are responsible for the stimulation of bone formation are to be characterized using this new rat model.

**References:**


4 Vanici I, a simple and reproducible model of spinal cord injury by epidural balloon infiltration in the rat, J of Neurotrauma 2001,Vol18,Nr.12